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A Clustering Protocol for WSN

Jingna Wang*1, Ying Chen 2, Hailin Feng 3

Library,school of mathematic and statistics, Shanxi radio and television university, Xidian University, Xi'an, China

*1417292017@qq.com; 221006827@qq.com; 3hlfeng@xidian.edu.cn

Abstract

A clustering protocol based on evolutionary algorithm for Wireless Sensor Networks is proposed. The difference between total energy consumption and single node energy consumption is taken into account while designing the clustering protocol, which can guarantee relatively better tradeoff between the lifetime and the stability period of the network. Finally, the simulation results show that the proposed protocol is much more efficient compared with LEACH and EAERP.

Keywords

Clustering; Network Lifetime; Wireless Sensor Networks

Introduction

Due to the restrictions of limited energy of a Wireless sensor network (WSN), achieving a better network performance and a longer network lifetime is of great importance. Clustering is considered to be a nice way to optimize energy to extend network lifetime. Generally,clustering algorithms include distributed and centralized. Distributed usually devise cluster head selection operator, by considering the residual energy of nodes[2,4,5,11], the distance from node to the sink, the node density, the degree of node[5], the number that node be cluster head and the round number of the network operation[1,4,7,12], etc. Distributed algorithm provide us with an effective way of better balancing the network load or other purposes. In centralized algorithm, the objective of cluster head selection, usually consider the total amount of various types of parameters, such as the total energy consumption and the average remaining energy of all the nodes [7], the total distance of each node to the base station [8]and the total number of cluster heads[9], etc. in order to prolong the network life. Network life for a WSN usually refers to the death time of the first node or a certain percentage of nodes. In this paper, the network lifetime is defined as the death time of the last alive node (LND), while the death time of the first node (FND) is named as stabilization period. [7] proposed a energy-aware evolutionary routing protocol (EAERP) to get better FND and LND, yet there are no qualitative and quantitative explanations for the relationship between the respective parameters of FND and LND.By considering the total energy consumption of the network and the sum of squared differences between the node energy consumption and the average energy consumption of the network (sum of squared deviations), this paper propose a clustering protocol based on evolutionary algorithms for wireless sensor networks.

Clustering Algorithm

Model Assumptions

we assume that the position of base station (BS) is fixed,nodes are randomly distributed and their locations are known.Each node is equipped with the same initial energy and has its own fixed identity (ID).Energy consumption model is given as follows

$$E_{TX}(l,d)=\begin{cases}E_{elec}\cdot l+\varepsilon_{fs}\cdot l\cdot d^2, & if\ d\le d_0\\ E_{elec}\cdot l+\varepsilon_{mp}\cdot l\cdot d^4, & if\ d>d_0\end{cases} \tag{1}$$

$$E_{RX}(l,d)=E_{elec}\cdot l \tag{2}$$

where $E_{TX}(l,d)$ *and* $E_{RX}(l,d)$ are the energy consumption for transmission and receiving respectively, l is the amount of data packets , d is the distance between two nodes, E_{elec} is the energy spent to operate the transceiver circuit, ε_{fs} and ε_{mp} are the energy consumption of free space model and multipath fading model, respectively. d_0 is the

critical distance between free space model and multipath fading model.

the cluster head selection according LEACH algorithm,

$$T(n)=\begin{cases}\dfrac{p}{1\text{-}p\times(r \bmod \frac{1}{p})} & \forall n\in G\\ 0 & \forall n\notin G\end{cases} \tag{3}$$

where n is the node ID, T(n) is a specific threshold for each node, p is the desired percentage of the CH nodes, r is the current round number, G is the set of nodes that have not been CHs in the last 1/p rounds.

Clustering Based on Evolutionary Algorithm

1) Population Establishment and Initialization

Set a total of N, each single node corresponds to an individual's gene. the number of individuals in each group is set to be n, then the n-th instance of one population can be expressed as I^n. If the node has no residual energy, the corresponding gene is -1. And if the node has remaining energy, and is selected to be a cluster head, then the corresponding gene is 1, otherwise 0, which means the node is a normal node. Similar to EAERP, population with n individuals can be defined as:

$$I_j^i=\begin{cases}1 & \text{if } E(node_j)>0 \ \text{ and } node_j=CH\\ 0 & \text{if } E(node_j)>0 \ \text{ and } node_j=non-CH\\ -1 & \text{if } E(node_j)=0\end{cases} \tag{4}$$

for $\forall i\in\{1,\cdots,n\}$ and $\forall j\in\{1,\cdots,N\}$.

according cluster head selection protocol, each individual is randomly initialized in the form of 0, 1 and -1 per round,then

$$I_j=\begin{cases}1 & \text{if } E(node_j)>0 \ \text{ and } random_j\le T(j)\\ 0 & \text{if } E(node_j)>0 \ \text{ and } random_j> T(j)\\ -1 & \text{if } E(node_j)=0\end{cases} \tag{5}$$

2) Fitness Function

Taking the difference between total energy consumption and single node energy consumption into consideration, we define fitness function operator as

$$f_{pro}(I^k)=\omega\cdot f_1(I^k)\cdot\gamma+(1-\omega)\cdot f_2(I^k), 0\le\omega\le 1 \tag{6}$$

$$f_1(I^k)=\sum_{i=1}^{n}(E_{con,i}-E_{ave})^2 \tag{7}$$

$$E_{ave}=(\sum_{i=1}^{n}E_{con,i})/n \tag{8}$$

where ω is the weigh parameter and γ is a constant which is used in balancing the magnitude between the operators $f_1(I^k)$ and $f_2(I^k)$. $E_{con,i}$ is the energy consumption of i-th node, E_{ave} is the average energy consumption of all nodes.and $f_2(I^k)$ is the same with fEAERP(Ik)in[7],

$$f_2(I^k)=(\sum_{i=1}^{nc}\sum_{s\in c_i}E_{TX_{s,CH_i}}+E_{RX}+E_{DA})+\sum_{i=1}^{nc}E_{TX_{CH_i,BS}} \tag{9}$$

where nc is the number of the cluster heads, ci is set of the member of cluster heads, nc is the total number of CHs, s∈ci is a cluster member to the i-th CH node.

3) *Crossover Operator*

Two positive integers between 1 and N are selected randomly to give two father individuals, I_1,I_2.Generating one random number $rand_c$ between 0-1, when randc <= pc(the crossover probability), a random integer r between 1 and N-1 is then produced, and performing the following operations:

$$I_1'=(I_{1,1}, \ldots, I_{1,r}, I_{2,r+1}, \ldots, I_{2,N}) \tag{10}$$

$$I_2'=(I_{2,1}, \ldots, I_{2,r}, I_{1,r+1}, \ldots, I_{1,N}) \tag{11}$$

I_1', I_2' will be the new quasi–offspring and perform the mutation operations followed.

4) *Mutation Operator*

The mutation operator in this paper is single point mutation.Each individual generated one random number randm between 0 and 1, if randm <= pm (mutation probability), then perform the following operation,

$$I_j^i{}' = \begin{cases} 1 - I_j^i, & \text{if } rand_m \le pm \text{ and } I_j^i \ne -1 \\ I_j^i, & \text{otherwise} \end{cases} \tag{12}$$

After mutation operation, the population will repeat the above process until the optimal solution is obtained or the largest evolution generation is reached.

Simulation and Analysis

We randomly deployed 100 nodes into a 100m×100m squared grid. The base station is located in the center of or the corner of the network. Set crossover operator pc=0.6, mutation operator pm=0.01 and the largest evolutionary generation is 20. The values of other parameters are listed in the table.1.

Fig.1 and Fig.2 are simulation results about network lifetime of two kind of networks while compare to LEACH and EAERP. These results illustrate the effectiveness of our protocol.

TABLE I. PARAMETERS OF THE SIMULATION

Parameter	Value
E_0 (Initial energy)	0.5 J
E_{elec}	50 nJ/bit
ε_{fs}	0.0012pJ/bit/m^4
ε_{mp}	10pJ/bit/m^2
E_{DA} (Data aggregation)	5nJ/bit/signal
Date size	4000 bits
$d0$	87 m

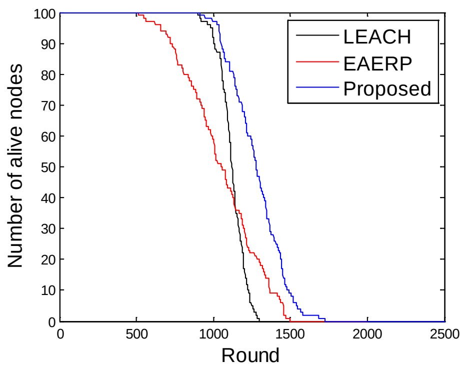

FIG.1 NUMBER OF ALIVE NODES FOR WSN, WITH BS CENTER-LOCATED.

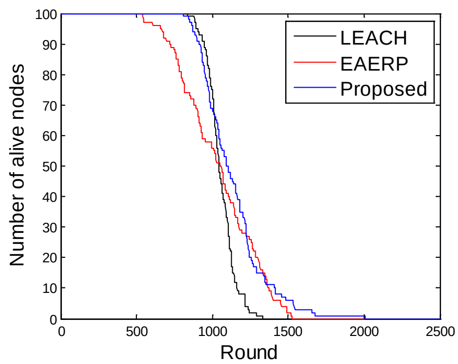

FIG.2 NUMBER OF ALIVE NODES FOR WSN, WITH BS CORNER-LOCATED.

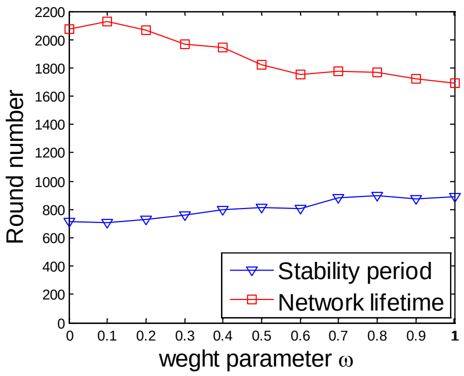

FIG3. THE VARIATION OF THE ROUND NUMBER ALONG WITH THE VARIATION OF WEIGHT PARAMETER

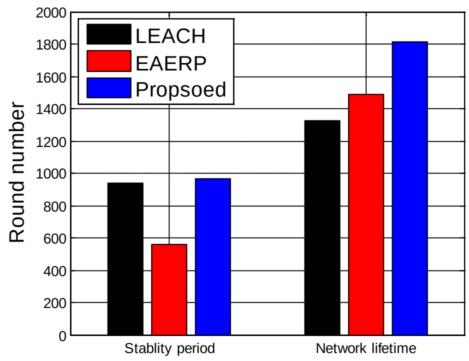

FIG4.SUMMARY OF STABILITY PERIOD AND NET WORK LIFETIME.

Fig. 3 is the result about the relationship between stability period of the network and the network lifetime. As is shown in Fig. 3, along with the increase of , the stability period of the network increased gradually on the whole, while the network lifetime decreases gradually on the whole. These results can be explained as: The smaller the single node energy consumption difference is, the more evenly burden nodes will have, thus the much harder to achieve that node energy exhausted prematurely, thus much longer stability period will be gotten.

Conversely, the smaller the energy consumption of the entire network, the smaller average single node energy consumption will have, thus the longer lifetime nodes will have, which means the much longer network lifetime will be extended. In short, the stability period and network lifetime have the reciprocal relationship.

By considering 10 networks with different node distributions, the average values of stability period and network lifetime, are shown in the Fig.4. As is shown in Fig4., the protocol we proposed can efficiently extend the stability period and network lifetime. Meanwhile, the proposed protocol also has good robustness.

Conclutions

Considering the relationship between stability period and the network lifetime, we proposed a clusting algorithms to get comprehensive factors which are more likely affecting the stability period and network lifetime. simulation and analysis results show the effectivity. And there existing mutual constraint relationship between the stability period (FND) and network lifetime.

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REFERENCES

[1] Abbasi and M. Younis, "A survey on clustering algorithms for wireless sensor networks," Computer Communications, vol. 30:2826-2841, June, 2007.

[2] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," The 33rd HICSS, vol. 2: 3005-3014, January, 2000.

[3] W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," IEEE T. Wirel. Commun., vol. 1: 660-670, October,2002.

[4] H. D. Tarigh and M. Sabaei, "A new clustering method to prolong the lifetime of WSN," ICCRD 2011, vol. 1:143-148, March, 2011.

[5] Younis and S. Fahmy, "HEED: A hybrid, energy-efficient, distributed clustering approach for Ad Hoc sensor networks," IEEE T. Mobile. Comput., vol. 3: 366-379, October, 2004.

[6] R.Zhou, M. Chen, G. Feng, H. Liu and S. He, "Genetic clustering route algorithm in WSN," ICNC 2010, vol. 8:4023-4026, August, 2010.

[7] E. A. Khalil and B. A. Attea, "Energy-aware evolutionary routing protocol for dynamic clustering of wireless sensor networks," Swarm and Evolutionary Computation, vol. 1:195-203, 2011.

[8] S. Jin, M. Zhou and A.S. Wu, "Sensor network optimization using a genetic algorithm," WMSCI 2003, vol. 1: 257-262, 2003.

[9] S. Mudundi and H. H. Ali, "A new robust genetic algorithm for dynamic cluster formation in wireless sensor networks," Proceedings of the 7th IASTED International Conferences on Wireless and Optical Communications, 360-367, 2007.

[10] Liu Yuhua, Gao Jingju, Zhu Longquan and Zhang Yugang, "A clustering algorithm based on communication facility in WSN," CMC 2009, vol. 2:76-80, January, 2009.

[11] Sim, K. J. Choi, K. J. Kwon and L. Jaiyong, "Energy efficient cluster header selection algorithm in WSN," : 584-587, March, 2009.

[12] G. Smaragdakis, I. Matta and A. Bestavros, "SEP: a stable election protocol for clustered heterogeneous wireless sensor networks," SANPA 2004, August, 2004.

Jingna Wang was born in shanxi in 1980, received his undergraduate degree in Mathematics from Yanan University in China in 2002 and a master degree in applied mathematics from Xidian University in China in 2010. She is now a engineers of Shanxi radio and television university.and her inerests include application of stochastic calculus and optimization to analyze problems arising in the fields of networking.